UNIVERSITI PUTRA MALAYSIA

PRETREATMENT OF SANITARY LANDFILL LEACHATE WITH A NATURAL POLYMER MORINGA OLEIFERA (KACANG KELOR) SEEDS EXTRACT AND HOLLOW FIBRE MICROFILTRATION MEMBRANE

EMAD SALIM MOHD. AMEEN

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By

EMAD SALIM MOHD. AMEEN

Thesis Submitted Fulfilment of the Requirement for the Degree of
Master of Science in the Faculty of Engineering
Universiti Putra Malaysia

June 2001

This Work is Dedicated
To
My Parents, Sister and Brothers

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

PRETREATMENT OF SANITARY LANDFILL LEACHATE WITH A NATURAL POLYMER *MORINGA OLEIFERA* (KACANG KELOR) SEEDS EXTRACT AND HOLLOW FIBRE MICROFILTRATION MEMBRANE

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June 2001

Chairman: Ir. Dr. Suleyman A. Muyibi

Faculty: Engineering

Due to population growing affluence, the fast development in industrial sector and improved standard of living, a huge volume of solid waste is being produced. The disposal of this numerous quantity of material in a sanitary landfill conveys with it an inherent potential for pollution of indigenous water resources. A major environmental impact resulting from the disposal of solid waste into a sanitary landfill occurs when water either from rainfall or groundwater passing through the refuse accumulates various contaminants including dissolved organic and inorganic components and decomposition products. This percolated liquid is called 'Leachate'. It is considered very harmful and toxic. Biological treatment is the most common system used to handle the leachate before discharge to water sources. Presence of toxic heavy metal in the leachate limit the activity of microorganisms, resulting in the decrease of the efficiency of the biological treatment to produce high effluent quality that will meet Malaysian Effluent Standard. Therefore a laboratory study using a bench scale model of three unit operations / processes of coagulation using

Moringa oleifera seeds as a natural coagulant, flocculation-sedimentation and micro-filtration was adopted to treat the leachate from Air Hitam Sanitary Landfill at Puchong, Selangor state of Malaysia. *Moringa oleifera* had achieved 43.75% Cadmium removal, 21.17% Total Chromium removal, 66.77% Lead removal, and 16% Iron removal. Also 55.42% of Total Suspended Solids, 9.98% of Total Dissolved Solids, and 24.16% of Volatile Suspended Solids were removed from the leachate after coagulation with an effective *Moringa oleifera* dosage. Micro-filtration hollow fibre membrane used decreased the Turbidity, Colour, Total Suspended Solids, Total Dissolved Solids, Volatile Suspended Solids, and Organic Matter in the leachate by 98.30%, 90.30%, 99.63%, 20.83%, 36.63%, and 21.87 respectively. Also it achieved 94% Cadmium removal, 29.81% Total Chromium removal, 73.2% Lead removal, and 18.28% Iron removal. Overall heavy metals removal from the leachate achieved by the bench scale model was 95.83% for Cadmium, 27% for Total Chromium, 79.9% for Lead, and 29.53% for Iron.

The results shown that *Moringa oleifera* is a promising natural polymer for removing heavy metals from the leachate, and may be used as a pre-treatment stage for biological treatment to eliminate a portion of the toxic heavy metals, which limits the activity of micro-organisms in the leachate.

Abstrak tesis yang dikemukakan kepada Senat Univerisiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

PRA-RAWATAN LEACHATE (AIR RESAPAN) DARI TAPAK PELUPUSAN SANITARI DENGAN MENGGUNAKAN EKSTRAK BIJI POLIMER *MORINGA OLEIFERA* (KACANG KELOR) DAN HOLLOW FIBER MEMBRAN MIKRO TURASAN

Oleh

EMAD SALIM MOHD. AMEEN

Jun 2001

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Dengan bertambahnya populasi penduduk, juga pembangunan yang pesat di dalam sektor industri serta taraf hidup yang semakin baik, mengakibatkan lebih banyak isipadu sisa pepejal dihasilkan. Pembuangan bahan-bahan dengan kuantiti yang banyak di dalam kawalan pembersihan bahan buangan yang membawanya secara semulajadi sebagai potensi kepada pencemaran sumber air tulen. Kesan yang amat besar ke atas alam sekitar akibat daripada pembuangan sisa pepejal yang berlebihan ke tapak pelupusan sanitari berlaku apabila air samada dari jumlah hujan atau air dari bumi yang melewati melalui sisa yang mengandungi bahan organik terlarut dan juga komponen bukan organik dan hasil sisa yang reput. Cecair yang terhasil ini dikenali sebagai leachate (air resapan). Cecair ini sangat berbahaya dan bertoksik. Rawatan secara biologi adalah salah satu sistem yang selalu digunakan untuk mengendalikan leachate sebelum dikeluarkan ke sumber air. Kehadiran logam berat toksik di dalam leachate menghadkan aktiviti mikroorganisma, mengakibatkan pengurangan keupayaan rawatan secara biologi untuk mengeluarkan hasil efluen yang tinggi bagi mencapai Akta Piawaian Kualiti Alam Sekitar Malaysia. Oleh yang

demikian, ujian makmal dijalankan dengan menggunakan model bench scale daripada tiga unit operasi / proses pengentalan menggunakan biji *Moringa oleifera* sebagai bahan kental semulajadi, flocculation-sedimentation dan mikro turasan, yang telah digunakan sebagai rawatan kepada leachate dari Tapak Pelupusan Sanitari, Air Hitam, Puchong, Selangor. *Moringa oleifera* telah mencapai 43.7% penyingkiran Kadmium, 21.17% penyingkiran Kromium, 66.77% penyingkiran Plumbum, dan juga penyingkiran 16% Besi. Juga 55.42% daripada Jumlah Pepejal Terampai, 9.98% daripada Jumlah Pepejal Terlarut, dan 24.16% daripada Pepejal Terampai Terperuwap yang telah disingkirkan daripada leachate selepas proses pengentalan dengan dosej *Moringa oleifera* yang lebih berkesan. Membran mikro turasan Hollow Fiber digunakan untuk mengurangkan Turbiditi, Warna, Jumlah Pepejal Terampai, Jumlah Pepejal Terlarut, Pepejal Terampai Terperuwap dan Bahan Organik di dalam leachate masing-masing ialah 98.30%, 90.30%, 99.63%, 20.83%, 36.63%, dan 21.87%. Ia juga mencapai 94% penyingkiran Kadmium, 29.81% penyingkiran Kromium, 73.2% penyingkirin Plumbum, dan 18.28% penyingkiran Besi. Secara keseluruhan penyingkiran logam berat daripada *leachate* telah dicapai dengan menggunakan model bench scale iaitu 95.83% Kadmium, 27% Kromium, 79.9% Plumbum, dan 29.53% Besi.

Keputusan telah menunjukkan bahawa *Moringa oleifera* merupakan penghasil polimer semulajadi yang baik untuk menyingkirkan logam berat daripada leachate, dan kemungkinan akan digunakan sebagai peringkat pra-rawatan untuk rawatan secara biologi supaya dapat menghapuskan bahagian toksik logam berat, yang menghadkan aktiviti mikroorganisma di dalam leachate.

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I certify that an Examination Committee met on 20th June 2001 to conduct the final examination of Emad Salim Mohd. Ameen on his Master of Science thesis entitled "Pretreatment of Sanitary Landfill Leachate with a Natural Polymer *Moringa oleifera* (Kacang Kelor) Seeds Extract and Hollow Fibre Microfiltration Membrane" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science.

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Date: 13 SEP 2001

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

EMAD SALIM MOHD. AMEEN

Date: 03/08/2001

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LIST OF ABBREVIATIONS

TSS	Total Suspended Solids
TDS	Total Dissolved Solids
VSS	Volatile Suspended Solids
COD	Chemical Oxygen Demand
BOD	Biochemical Oxygen Demand
CFMF	Cross Flow Micro-filtration
Cd	Cadmium
Cr	Chromium
Pb	Lead
Fe	Iron
MF	Micro-filtration
UF	Ultra-filtration
NF	Nano-filtration
RO	Reverse Osmosis

CHAPTER I

INTRODUCTION

A considerable amount of solid waste is produced in most of the industrialized countries. Most of this waste is deposited in- controlled sanitary landfills. As water percolates through solid domestic wastes, which have been deposited in a landfill, it dissolves organic and inorganic components and decomposition products, giving rise to a polluted liquid known as leachate. Two major sources of environmental pollution are typically associated with solid waste landfilling. These include surface and groundwater pollution from leachate formation and the production of volatile gases. Leachates are defined as hazardous wastewater. Their disposal is recognized as one of the most difficult tasks associated with the operation of landfills.

The composition of leachate is variable and depends on many factors, but leachates from relatively recent emplaced waste often contain high levels of COD, BOD and Ammoniacal nitrogen, in addition to high concentrations of metals such as Iron, Manganese, Calcium and sometimes Zinc (Robinson and Maris, 1979). Organic and inorganic matter present in the refuse and the products of decomposition can be leached by water, either rainfall or groundwater, passing through the wastes. This is a potential cause of serious water pollution. The containment and treatment of leachate may therefore be necessary, to avoid or minimize contamination of adjacent ground or surface water resources.

Lu *et al.* (1985) considered that in some cases it will not be economically feasible to eliminate leachate production from these refuse areas and treatment of the leachate will be necessary. Either chemical or biological treatment should be

effective. It is also possible that a combined treatment system in which the major treatment is done by chemical and physical means, with the polishing being done in lagoons or other biological processes being the most economical.

Objectives

The objectives of this study were:

1. To investigate the treatability of landfill leachate, using *Moringa oleifera (Kacang Kelor)* seed for pretreatment of the leachate.

2. To evaluate the efficiency of the physical-chemical processes viz. coagulation-flocculation-sedimentation and filtration using hollow fiber micro-filtration membrane in the pretreatment of leachate.

Scope of Study

A laboratory study using a bench scale model of three unit operations involved processes of coagulation-flocculation using *Moringa oleifera (Kacang Kelor* seeds as a natural coagulant), sedimentation and micro-filtration, have been adopted to treat Air Hitam sanitary landfill leachate. The leachate was analyzed before treatment, after coagulation process and after micro-filtration process, for the parameters: pH, Temperature, Turbidity, Alkalinity, Acidity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Volatile Suspended Solids (VSS), Chemical Oxygen Demand (COD) using Standard Methods (APHA et al., 1998), and Heavy Metals viz. Cadmium (Cd), Chromium (C), Lead (Pb), and Iron (Fe) using

Inductively Coupled Plasma Mass Spectrometer. These heavy metals were chosen due to its serious impact on the environment as it was mentioned in the Indah Water report (1997) on Trenching (Environmental Protection-Monitoring of Completed Trench-fills). The results of the analyzed leachate before and after treatment for the parameters mentioned above have been compared to evaluate the success and efficiency of the laboratory study which included: bench scale model, coagulation-flocculation process with *Moringa oleifera* as a coagulant and filtration process using micro-filtration hollow fiber membrane.

Jar test have been used to determine the effective concentrations of *M. oleifera* and the optimum speed and time for rapid and slow mixing. It was also adopted to determine the effective dosage of *M. oleifera* seed suspension (stock solution) before each batch run.

Justification of the Study

In an effort to minimize the environmental impacts resulting from leachate contamination, many treatment processes have been studied. Biological treatment (aerobic and anaerobic), physical treatment by Micro-filtration, Ultra-filtration, Nano-filtration and Reverse osmosis, also the combination of these two processes and other special methods have been adopted to treat landfill leachate. Each process has different cost and efficiency in treating the leachate to remove unacceptable parameters in it in order to minimize the environmental pollution. Biological methods are very effective for the treatment of landfill leachate with a high value of BOD, but are ineffective if recalcitrant organic compounds are present, so that they must be supported by physical-chemical process (Chiang et al.,

existence of heavy metals viz. Cadmium, Chromium, and Lead...etc in the leachate which are considered very toxic limits the activity of microorganisms and decrease the efficiency of the biological treatment. In this study the feasibility of using *Moringa oleifera* (the natural organic polymer available in Malaysia) as a coagulant, as a new and economic method, followed by filtration process using hollow fiber Micro-filtration membrane to pretreat the leachate for the parameters: pH, Turbidity, Acidity, Alkalinity, Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Volatile Suspended Solids (VSS), and Heavy metals viz. Cadmium (Cd), Chromium (C), Lead (Pb), and Iron (Fe) were investigated.

Potential Benefits

Moringa oleifera is considered as one of environmentally acceptable coagulant to be used in water and wastewater treatment instead of alum and synthetic polymers. In addition to this use, *Moringa oleifera* will provide many other benefits like: creation of new job opportunities, establishment of seed processing industries, while activated carbon can be produced from the husks and shell of *M. oleifera*. Oil extract from *Moringa oleifera* seeds can be used for edible or industrial, also the *M. oleifera* trees will provide protection to the soil from erosion and desertification.

Using of the natural coagulant '*Moringa oleifera*' in developing countries could effectively alleviate their economic situation and allow further extension of water supply to rural areas. Also it can be used as an efficient alternative to the chemical materials in the entire world.